

PCT

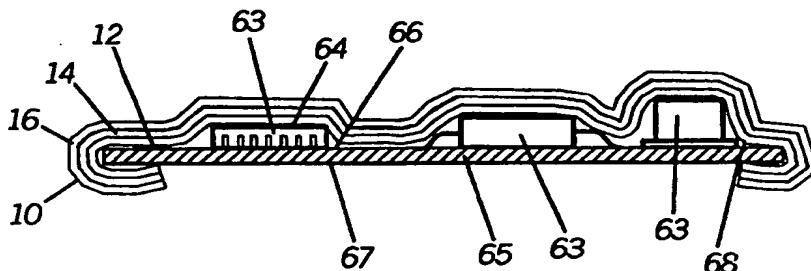
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(54) Title: CONFORMAL SHIELD AND METHOD FOR FORMING SAME



60

(57) Abstract

A conformal shield (10) includes a conformal shield base (15), and a conductive layer (16). The conformal shield base (10) has a first conformable insulating material (12) having a characteristic softening point at a first temperature. A second conformable insulating material (14), which has a characteristic softening point at a temperature higher than the first temperature, is overlaid on the first conformable insulating material (12). The conductive layer (16) is disposed on the conformal shield base (15) to form the shield (10).

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## CONFORMAL SHIELD AND METHOD FOR FORMING SAME

10

### Technical Field

This invention relates in general to shields used in electronic devices, and more particularly, to shields for protecting electrical components.

15

### Background

Electronic products typically have electrical circuitry implemented on a circuit substrate, such as a printed circuit board. The performance of the circuitry may be adversely affected by factors such as  
20 electromagnetic interference (EMI), radio frequency interference (RFI), electrostatic discharge (ESD), and environmental elements. The sources of interference may be internal or external to the product. For example, many electrical components emit radio frequency (RF) signals which may adversely affect the operation of other portions of the circuitry.  
25 Moreover, these RF signals may cause interference for other electronic devices operating nearby.

Typically, a product designer incorporates shields, or other protective devices, to protect critical portions of the circuitry, or specific components. For example, to protect against EMI, a critical component  
30 is enclosed in EMI shield formed to substantially enclose the component and onto the circuit substrate. Components having a high EMI output are identified and electromagnetically isolated using EMI shields. Moreover, the shield components may be a part of a larger electrical module, such as power amplifier, which is preferably housed in EMI  
35 shielded enclosures to provide further protection.

Prior art shielding techniques include metal cans, metal foil claddings, wire mesh screens, and plastic enclosures or cases having metalized coatings. However, several problems associated with prior art

shielding techniques need to be overcome. For example, a product may have many components requiring EMI shielding from other components within the product as well as from external sources. Depending on the number of the shields needed, significant weight and cost may be added to the product. Moreover, space must be allocated on the circuit board to accommodate the shields which reduces the space available for other components. Additionally, prior art shielding techniques typically do not facilitate shielding decisions made late in the product design cycle, which may be necessary after product testing. Consequently, major redesigns may be needed to add shields where the need was unanticipated.

The trend toward increasingly smaller products minimizes the space available on the circuit board for many of the shields typically used in the prior art. Cost, weight, and design convenience are also important factors in evaluating shielding options. These and other issues make prior art shielding techniques inadequate for some applications. Therefore, there exists a need for a new approach to EMI and other types of shielding.

## **20 Brief Description of the Drawings**

FIG. 1 is a cross-sectional view of a conformal shield in accordance with the present invention.

FIG. 2 is a cross-sectional view of a second embodiment of the conformal shield of the present invention.

25 FIG. 3 is a cross-sectional view of a third embodiment of the conformal shield of the present invention.

FIG. 4 is a cross-sectional view of a fourth embodiment of the conformal shield of the present invention.

30 FIG. 5 is a cross-sectional view of a fifth embodiment of the conformal shield of the present invention.

FIG. 6 is a perspective view of a shielded circuit assembly in accordance with the present invention.

FIG. 7 is a cross-sectional view of the shielded circuit assembly of FIG. 6.

35 FIG. 8 is a fragmentary perspective view of a radio in accordance with the present invention.

### Detailed Description of the Preferred Embodiment

The present invention provides for a conformal shield for shielding an article. The shield is described as being conformal because it is formed to conform or adapt to the shape of the article to be shielded. The conformal shield may be used to shield an electrical component, a circuit assembly or portions thereof, an electronic device, such as by shielding the device housing, and the like. Shielding may be desirable to protect circuit assembly components from internally and externally sourced interfering elements. For example, circuit assembly components can be shielded to provide protection from electro-magnetic interference, electro-static discharge, and environmental elements such as moisture, dust, and environmental contaminants. Additionally, by shielding a particular component, that component is protected from potential interference from other components of the circuit assembly. Moreover, other components are protected from interference sourced at the particular component. The present invention provides novel combinations of materials and procedures for use in the construction of the conformal shield, and novel applications therefor.

Referring to FIG. 1, a cross-sectional view of a conformal shield 10 is shown, in accordance with the present invention. The conformal shield 10 is formed from a conformable material that can be adapted to the shape of articles upon which it is disposed. In the preferred embodiment, the conformal shield 10 has a low temperature softening point and is responsive to the application of thermal energy, optionally assisted by a vacuum process, to shrink around or conform to an article which is to be shielded. Thus, the conformal shield 10 is typically disposed over the article and thermally activated to conform to the article.

The conformal shield 10 comprises a base 15 and a conductive layer 16 disposed on the base 15. The conformal shield base 15 includes first and second layers 12, 14 of conformable insulating material. The material of the first conformable insulating layer 12 is selected to have a characteristic softening point at a low processing temperature. Polypropylene, polyethylene, and other polymers with a low processing temperature, are among the materials suitable for forming the first insulating layer 12. The second conformable insulating layer 14 is

formed to have a characteristic softening point at a temperature higher than the processing temperature of the material of the first insulating layer 12, under similar conditions. In the preferred embodiment, a thin continuous sheet of polypropylene is used for the first insulating layer 12, and nylon, which has a higher processing temperature than polypropylene, is used for the second insulating layer 14. The conformal shield base 15 is formed by overlaying or disposing the second insulating layer 14 on the first insulating layer 12. Preferably, the first and second insulating layers 12, 14 are co-laminated, or otherwise attached, to facilitate processing. The significance of the different processing temperature characteristics of the insulating layers will be described in more detail below.

The conductive layer 16 comprises conductive material disposed on or overlaid onto the conformal shield base 15. Preferably, the conductive layer 16 is disposed on the second insulating layer 14 of the conformal shield base 15. In the preferred embodiment, the conductive layer 16 is a conductive fabric formed from polyester impregnated or coated with conductive material such as metal. The metal should be malleable, or one with a low softening point, so that the metal becomes pliable during processing. Materials such as conductive plastics, conductive paints, metal films, metal meshes or screens, or semiconducting material, could be used for this layer. Magnetic organic/molecular based materials may also be used in the conductive layer 16. The properties of the metal may be chosen for a proper thermal, grounding, and/or shielding requirements. For example, if the conformal shield 10 is to be used as an electromagnetic interference shield, a conductive material such as copper, silver, or nickel, would be chosen. If heat dissipation characteristics were of primary importance, a conductive material comprising aluminum nitride might be preferred. Techniques for forming the conductive layer 16 include vacuum or thermal spray metalization, electroless plating, and the like.

The conformal shield 10 has a low temperature softening point and is responsive to the application of thermal energy, optionally assisted by a vacuum process, to shrink around or conform to articles upon which it is disposed. Ordinarily, the conformal shield 10 is applied to an article such that the insulating layer having the lower temperature softening

point, i.e., the first insulating layer 12, is positioned closer to the article than the insulating layer having the higher temperature softening point material, i.e., the second insulating layer 14. Sufficient thermal energy is applied to the conformal shield 10 so as to soften the material of the first insulating layer 12 but not enough to soften the material of the second insulating layer 14. Consequently, the softened first insulating layer 12 adheres to the article pulling the other layers along. Yet, the second insulating layer 14, not having reached its softening point, maintains its structural integrity, thereby providing support for the conductive layer 16 and structural form for the shield.

Variations in the construction of the conformal shield 10 impart different characteristics to the shield. In FIG. 2, a second conformal shield 20 is shown, in accordance with the present invention. The second conformal shield 20 is of similar construction to the first 10, except that a third layer 22 of conformable material forms a protective covering for the conductive layer 16. Such a layer may be formed from corrosion-resistant metal, corrosion inhibiting organic material, plastic, or other materials suitable for use as an environmental protectant. FIG. 3 shows a third conformal shield 30 having a second conductive layer 32 disposed on the first conductive layer 16. This second conductive layer 32 can be formed to have characteristics to serve a different function than that of the first conductive layer 16. For example, the second conductive layer 32 could be formed to have high heat dissipation characteristics, while the first conductive layer 16 has high electrical conductivity for electromagnetic interference protection. Additionally, multiple conductive layers can be used to accommodate the needs of a variety of shielding applications. FIG. 4 shows a fourth conformal shield 40, similar in construction to the third conformal shield 30, in which a third layer of conformable insulating material is disposed between the conductive layers 16, 32 to further enhance shielding performance.

Referring to FIG. 5, a fifth conformal shield 50 is shown, in accordance with the present invention. The construction of the fifth conformal shield 50 varies from that of the first four conformal shields 10, 20, 30, 40 described above. In this case, a conductive layer 54 is disposed on a first layer 52 of conformable insulating material having a characteristic softening point at a low processing temperature. A second

layer 56 of conformable insulating material, also having a characteristic softening point at a low processing temperature, is disposed or overlaid on the conductive layer 54. The materials of the first and second insulating layers 52, 56 may be similar or may have softening points at a substantially equal temperatures. A third layer 58 of conformable insulating material, having a characteristic softening point at a temperature higher than that of the material of the first and second insulating layers 52, 56, is disposed on the second insulating layer 56. The second and third insulating layers 56, 58 function as the conformal shield base 15 described above.

Referring to FIG. 6, a shielded circuit assembly 60 is shown in accordance with the present invention. The shielded circuit assembly 60 includes a circuit substrate 65, such as a printed circuit board, electrical or other circuit components 63 disposed on the circuit substrate 65, and the first conformal shield 10, disposed so as to conform about the component and at least a portion of the circuit substrate. The resulting structure is a substantially enclosed circuit assembly 60 which provides shielding to individual circuit components 63. Although, the first conformal shield 10 is used for the purposes of discussion, one skilled in the art would appreciate that the conformal shield could be constructed in a manner similar to any of the conformal shields FIGs. 2-5 described above, or by using logical extensions to the concepts embodied therein.

Referring to FIG. 7, a cross-sectional view of the shielded circuit assembly 10 is shown. The circuit substrate 65 is a printed circuit board which houses electrical circuitry including the electrical components 63. The printed circuit board 65 has first and second opposing surfaces 66, 67. The first surface 66 has electrical components 63 mounted thereon and the second surface 67 has an exposed ground plane thereon. The circuit assembly 10 may be combined with other electrical modules and circuitry to implement a product or device. In the preferred embodiment, the circuit assembly 10 implements a major portion of a two-way portable radio, and includes communication circuitry for communicating over a radio frequency channel. The electrical components 63 include a power amplifier module 64 which is typically a source of significant electro-magnetic interference. Additionally, the power amplifier module 64 typically requires a heat dissipation path for

dissipating excessive heat generated by this module. The circuit assembly 10 may also include electrical components 63 which are sensitive to electro-magnetic interference and which can be adversely affected by interference generated by the power amplifier module 64 among other sources. Accordingly, the conformal shield 10 is disposed over each component 63 such that each component 63 is substantially enclosed.

In a primary application of the present invention, the conductive layer 16 of the conformal shield 10 provides electro-magnetic interference shielding. Preferably, the conductive layer 16 is electrically grounded, such as by grounding to the circuit substrate 65, to provide shielding to prevent radio frequency emissions from entering or leaving protected areas. The first insulated layer 12 ordinarily makes contact with the electrical component 63 and helps protect the electrical components 63 and other portions of the circuitry on the circuit substrate 65 from electrical shorts.

In constructing the shielded circuit assembly 10, the circuit substrate 65 is populated with electrical components 63 and electrical circuitry to form a functional electrical module. The circuit substrate 65 is then encased with the conformal shield 10 such that the electrical components 63 and at least a portion of the circuit substrate 65 is covered by the conformal shield 10. The conformal shield 10 can be applied to the circuit substrate 65 by vacuum forming the conformal shield 10 onto the circuit substrate 65. Alternatively, the conformal shield 10 may be preformed on a mold of the circuit substrate 65 or other article which is to be shielded. Thermal energy is then applied to the conformal shield 10 such that the first insulating layer 12 reaches its softening point. The first insulating layer 12 conforms to the circuit substrate 65 and electrical components 63. Preferably, the conductive layer 16 is applied to the conformal shield base 15 to form the conformal shield 10 before vacuum forming occurs. The conformal shield 10 may also be constructed by first applying the conformal shield base 15 over the circuit substrate 65, then disposing the conductive layer 16 onto the conformal shield base 15, such as by metalizing the conformal shield base 15 while on the circuit substrate 65. Commonly available shrink or blister packaging technology can be used as a starting point for developing a manufacturing process.

Conventionally, EMI shielding is provided by enclosing critical components and/or the entire circuit assembly within a metal can which requires that space be reserved on the circuit assembly to accommodate the cans. The use of the conformal shield 10 for EMI shielding  
5 significantly reduces the number of parts required by eliminating the need for metal cans as shields. Furthermore, the additional space required on the circuit substrate to accommodate the shielding is relative small. This shielding approach is particularly useful when addressing product miniaturization and manufacturing cost reduction.

10 Referring to FIG. 8, a fragmentary perspective view of a radio 80 is shown, in accordance with the present invention. The radio 80 is a portable two-way radio electronic device incorporating well known communications circuitry for communicating over a radio frequency channel. The radio 80 includes a radio housing 82 which houses the  
15 shielded circuit assembly 60 and other internal components of the radio 80. The radio housing 82 is a structural component which is itself shielded by a radio conformal shield 85 formed according to the present invention. The radio conformal shield 85 is disposed on the interior portion of the radio housing 82 and conforms to the interior of the radio  
20 housing 82. This radio shield 85 protects the internal components of the radio 80 from externally sourced interference, and also reduces radio emissions. As radio products become smaller, the benefits of such radio shields become greater.

The conformal shield 10 of the present invention offers significant  
25 benefits. These benefits include simple design and construction, low cost, and compact design. The conformal shield 10 provides EMI protection without adding significant size or weight to a product. Additionally this shielding technique can be used on articles, such as structural components, which were not originally designed for EMI  
30 shielding. Moreover, design cycle time and design costs can be saved by eliminating the need to accommodate conventional metal can shields. The elimination of metal can shields also reduces the part count and overall product weight. A conformal shield 10 can be constructed to provide additional features. For example, the shielding material may be  
35 chosen to provide electrostatic discharge protection, electromagnetic pulse protection, and also to provide a thermal path for heat dissipation.

Moreover, by fully encasing the article to be shielded, an effective moisture seal can be created for the article.

What is claimed is:

## Claims

1. A conformal shield, comprising:  
5 a conformal shield base, comprising:  
a first conformable insulating material having a  
characteristic softening point at a first temperature;  
a second conformable insulating material overlaying the first  
conformable insulating material, the second conformable  
10 insulating material having a characteristic softening point  
at a second temperature higher than the first temperature;  
and  
a first conductive layer disposed on the conformal shield base.
- 15 2. The conformal shield of claim 1, wherein the first conductive  
layer is disposed on the second conformable insulating material.
3. The conformal shield of claim 1, further comprising a second  
conductive layer disposed on the first conductive layer.
- 20 4. The conformal shield of claim 1, further comprising a third  
conformable insulating material disposed between the first and second  
conductive layers.

5. A conformal shield, comprising:
- a first conformable insulating material having a characteristic softening point at a first temperature;
  - 5 a conductive layer disposed on the first conformable insulating material;
  - a second conformable insulating material disposed over the conductive layer, the second conformable insulating material having a characteristic softening point at a second temperature;
  - 10 and
  - a third conformable insulating material disposed on the second conformable insulating material, the third conformable insulating material having a characteristic softening point at a third temperature higher than the first temperature and higher
  - 15 than the second temperature.

6. The conformal shield of claim 5, wherein the first and second temperatures are substantially equal.

7. A shielded article, comprising:  
an article; and  
a conformal shield disposed over at least a portion of the article  
5 and conforming to at least a portion of the article, the conformal  
shield comprising:  
a conformal shield base, comprising:  
a first conformable insulating material having a  
characteristic softening point at a first temperature; and  
10 a second conformable insulating material overlaying the  
first conformable insulating material, the second  
conformable insulating material having a characteristic  
softening point at a second temperature higher than the  
first temperature; and  
15 a first conductive layer disposed on the conformal shield base.
8. The shielded article of claim 7, wherein the article comprises a  
circuit substrate having electrical components thereon.
- 20 9. The shielded article of claim 12, wherein the article is a radio  
housing having an interior portion, and the conformal shield is disposed  
about the interior portion.

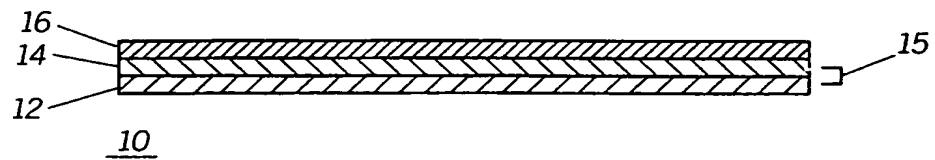
10. A method of forming a conformal shield on an article, the method comprising the steps of:

- 5       providing a first conformable insulating material having a  
          characteristic softening point at a first temperature overlaid  
          with a second conformable insulating material having a  
          characteristic softening point at a second temperature higher  
          than the first temperature to form a conformal shield base; and
- 10       disposing a first conductive layer on the second conformable  
          insulating material;
- providing an article;
- vacuum forming the conformal shield base onto the article;
- applying thermal energy to the conformal shield base such that the
- 15       first conformable insulating material reaches the first  
          characteristic softening point and the conformal shield base  
          conforms to the article.

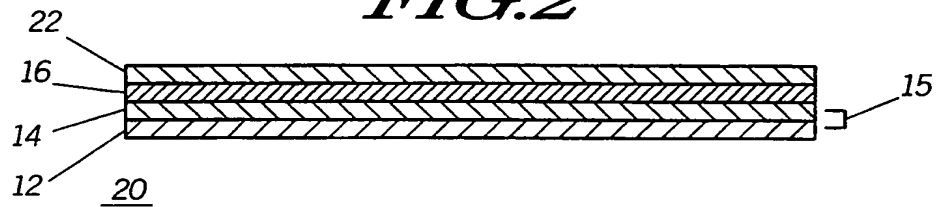
11. A method of forming a conformal shield for an article, the method comprising the steps of:

- 5       providing a conformal shield base having a conformable  
          insulating material;
- disposing a first conductive layer on the conformal shield base;
- providing a mold of an article;
- vacuum forming the conformal shield base onto the mold; and
- 10       applying thermal energy to the conformal shield base such that the  
          conformal shield base conforms to the mold.

**FIG.1**



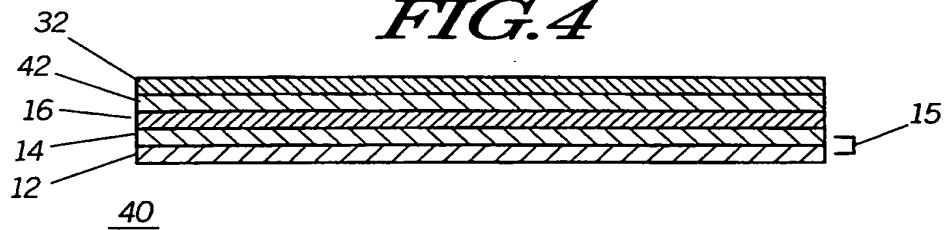
**FIG.2**



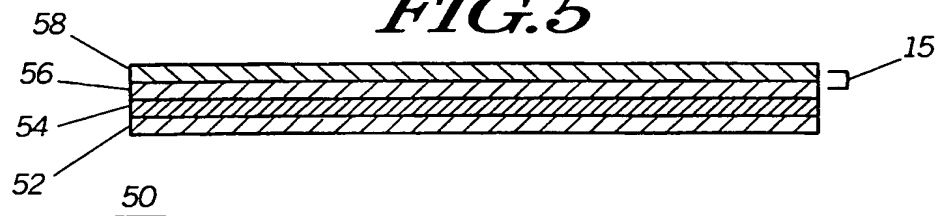
**FIG.3**



**FIG.4**

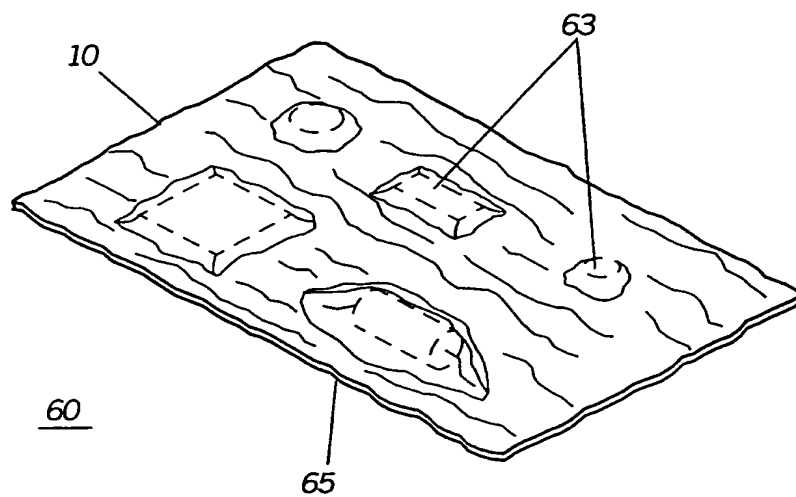


**FIG.5**

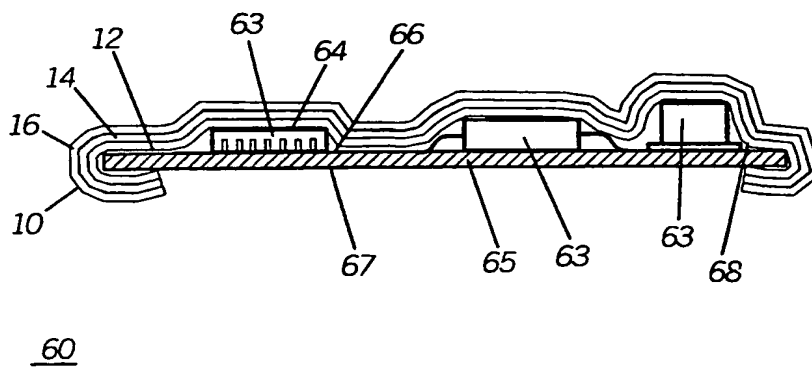


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**FIG. 6**

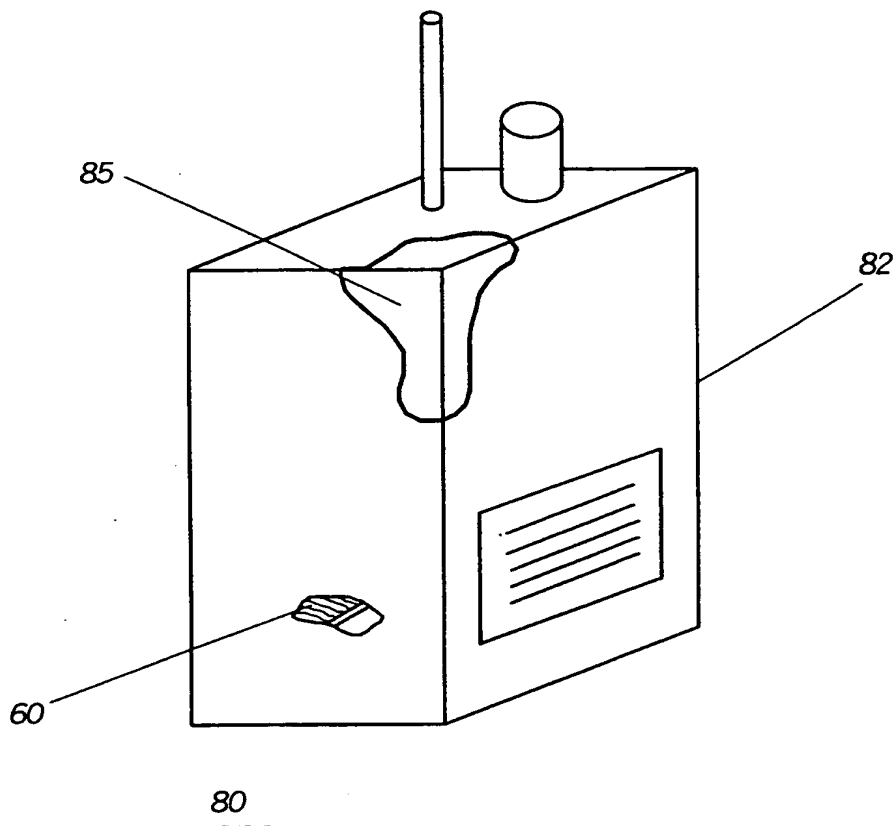


**FIG. 7**



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*FIG. 8*



## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US95/05052

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :H05K 9/00

US CL :174/35MS

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 174/35R,35GC,35MS;257/659;361/816,818;428/209,694RL

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US,A, 5,166,864 (CHITWOOD ET AL) 24 November 1992, see entire document.	1-2 ----- 3-11
X --E Y	US, A, 5,407,865 (GLOVATSKY ET AL) 18 April 1995, see Fig. 2.	1-2 ----- 3-11
A	US,A, 5,147,694 (CLARKE) 15 September 1992, see entire document.	1-11
A	US,A, 5,260,128 (ISHII ET AL) 09 November 1993, see entire document.	1-11
A	US,A, 4,542,076 (BEDNARZ ET AL) 17 September 1985, see entire document.	1-11

☐ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

Special categories of cited documents:	
*A* document defining the general state of the art which is not considered to be of particular relevance	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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*O* document referring to an oral disclosure, use, exhibition or other means	*A* document member of the same patent family
*P* document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

15 JUNE 1995

Date of mailing of the international search report

11 JUL 1995

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# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US95/05052

## Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
  
2. ☒ Claims Nos.: 9  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:  
  
Claim 9 was dependent on claim 12 which does not exist.
  
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
  
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.  
☐ No protest accompanied the payment of additional search fees.